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INTERNATIONAL
FOOD POLICY
RESEARCH
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Energy, Water and Food under Climate Change: Tradeoffs and Policies

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RESEARCH
PROGRAM ON
Water, Land and
Ecosystems



Outline

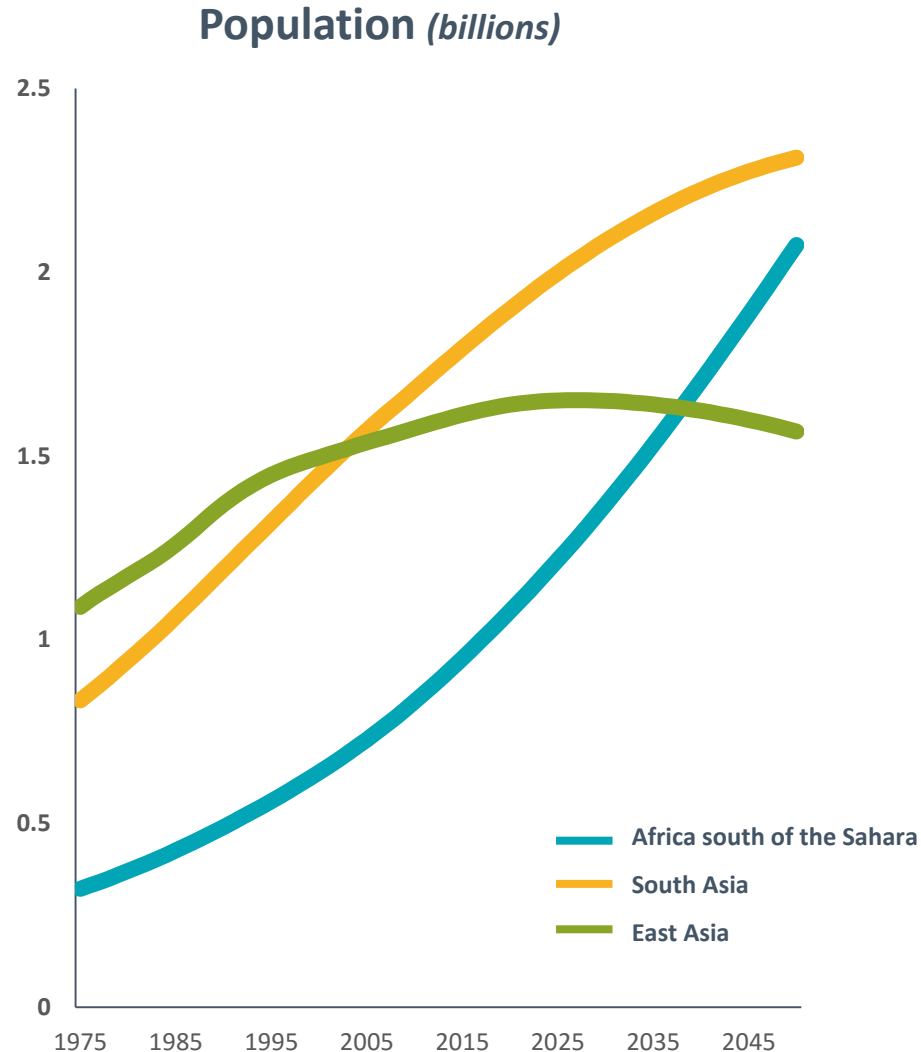
- Trends and Challenges for Food Security, Water Scarcity, and Energy Use
- Impact of Energy Taxes and Policy on Food Security and Water Scarcity: Scenarios to 2050
- Conclusions

Trends and Challenges for Food Security, Water Scarcity, and Energy Use

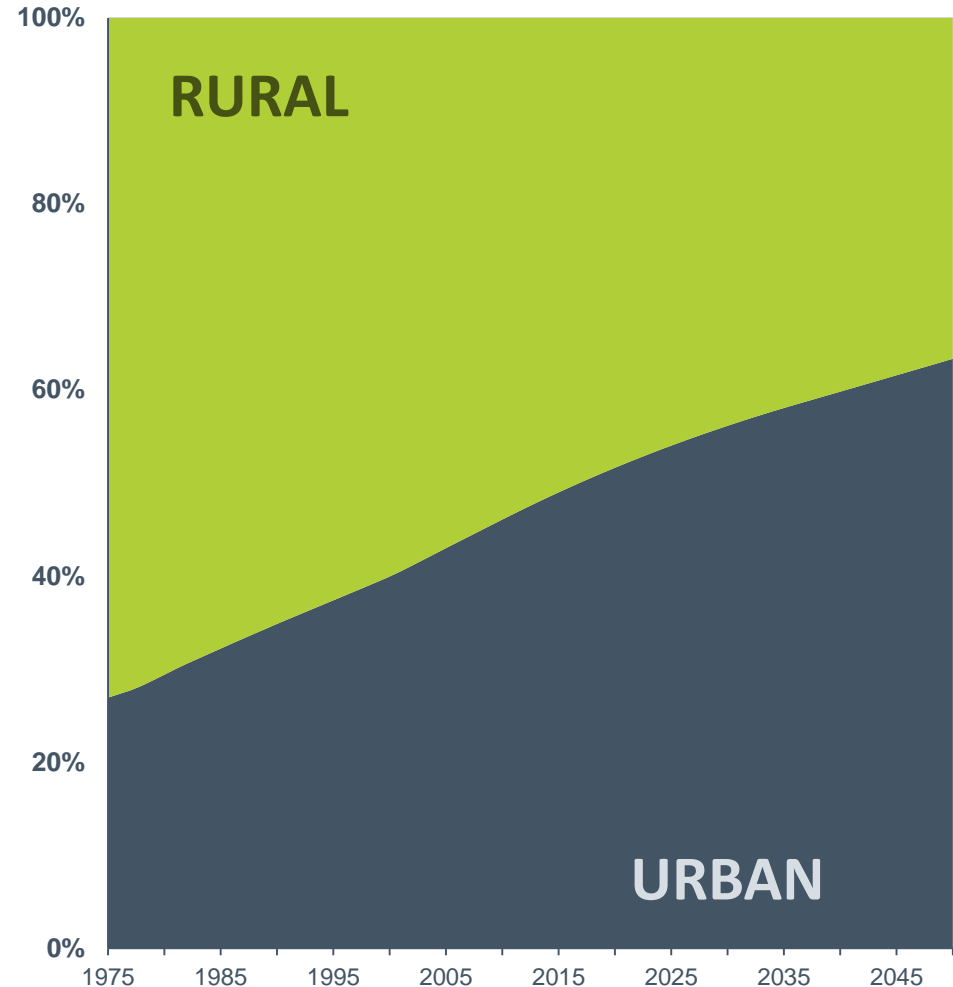
Background and Objective

- In September 2015, UN members adopted the Sustainable Development Goals
 - access to food, nutrition, safe water and modern energy for all
 - strong environmental protection, including reductions in greenhouse gas emissions (GHG)
- Potential tradeoffs between these goals, related targets and indicators
- Need to identify policies that achieve win-win solutions
- To assess the impact of energy (carbon) taxes on food security and water scarcity under climate change

Population: Rapid growth in Africa. Developing world urbanizes.

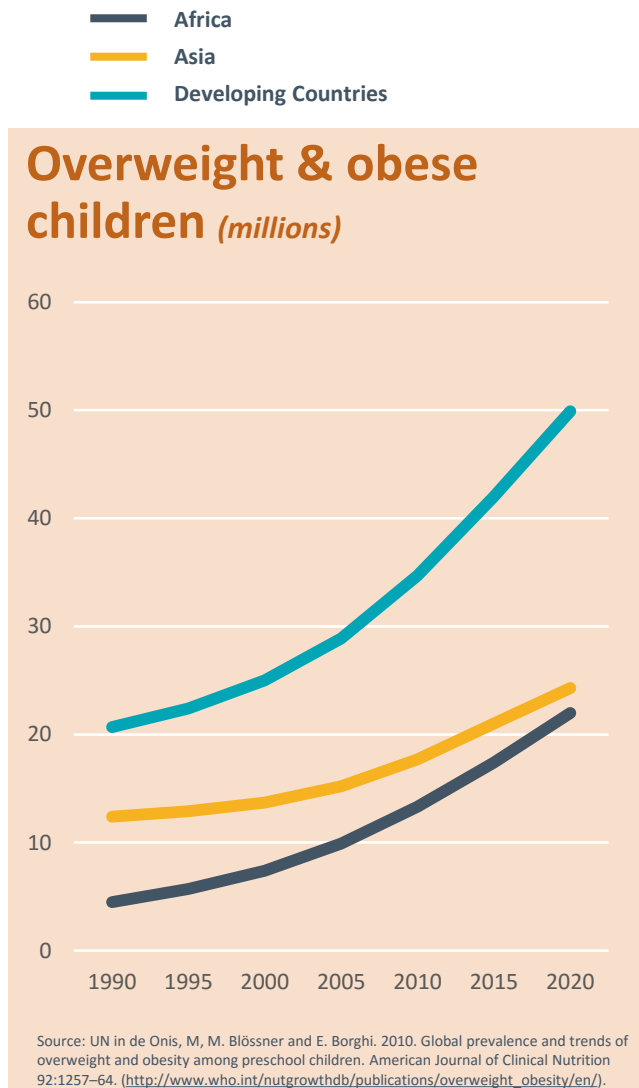
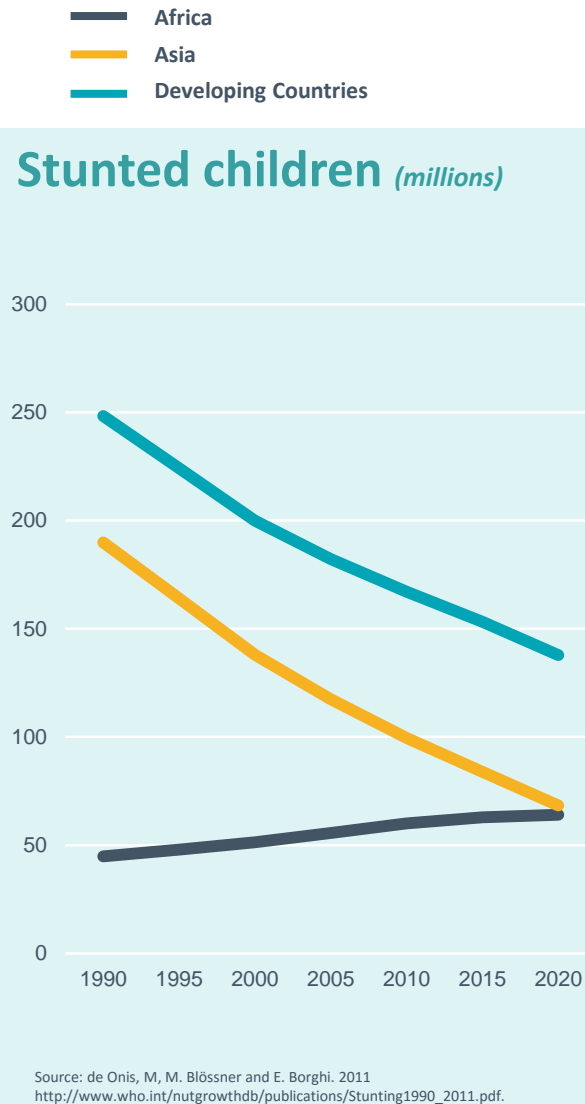
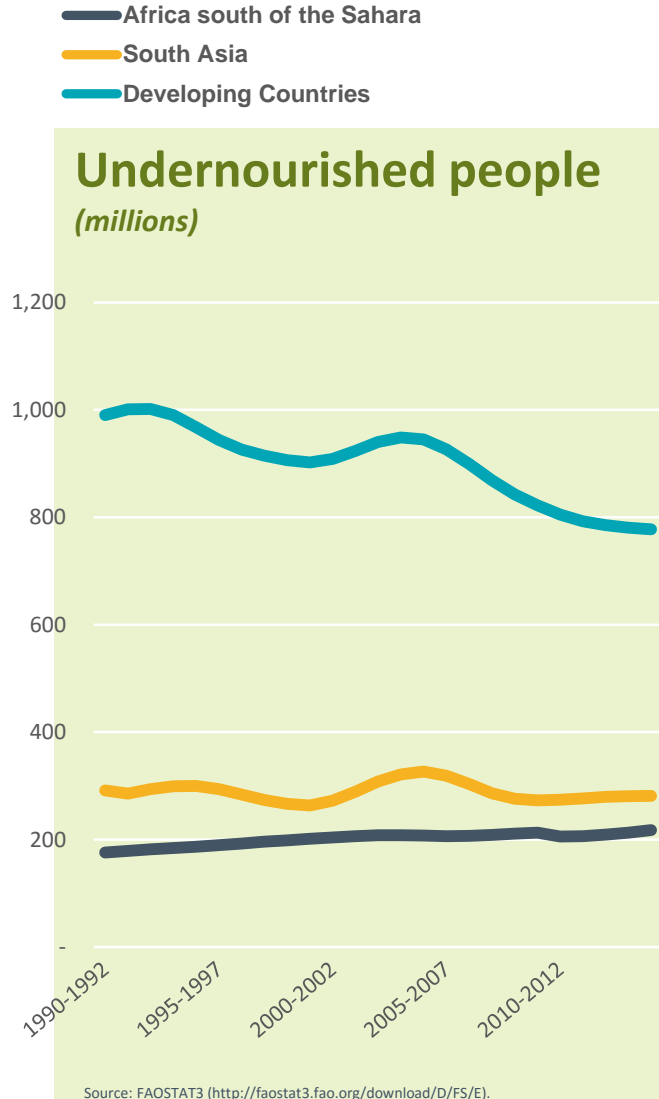


A demographic shift in developing countries



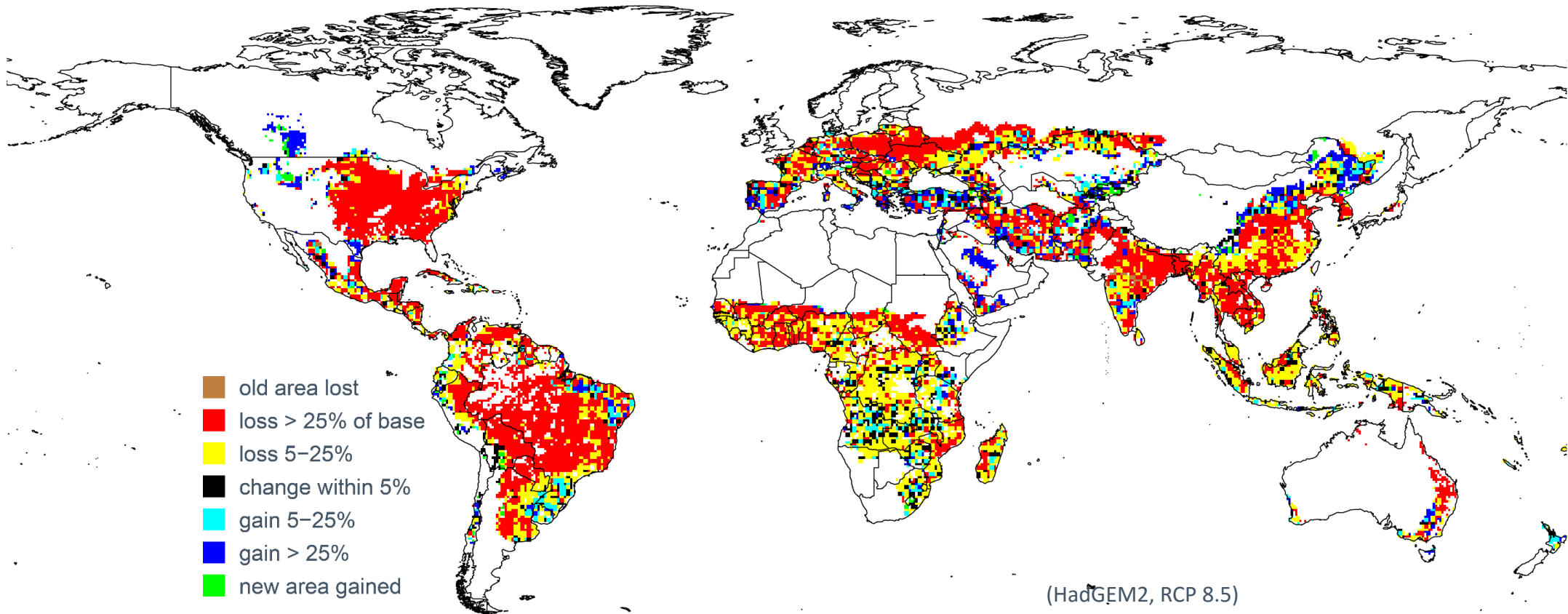
Source: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, CD-ROM Edition.

Slow decline in malnourishment. Alarming increase in obesity.



Heavy toll on **rainfed maize** with climate change.

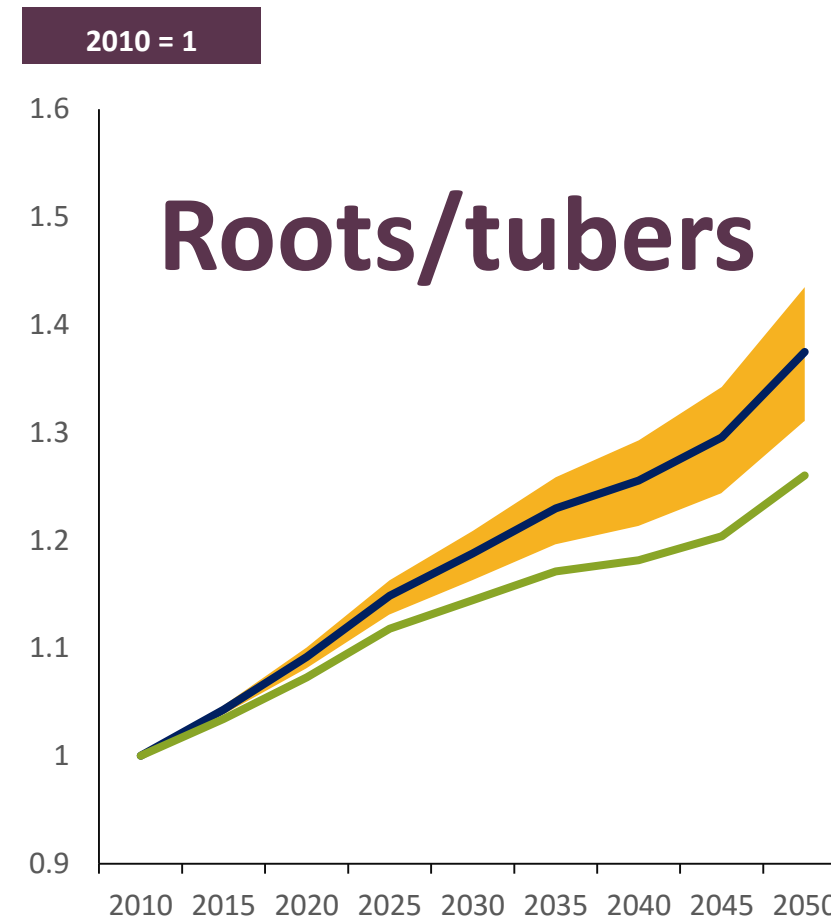
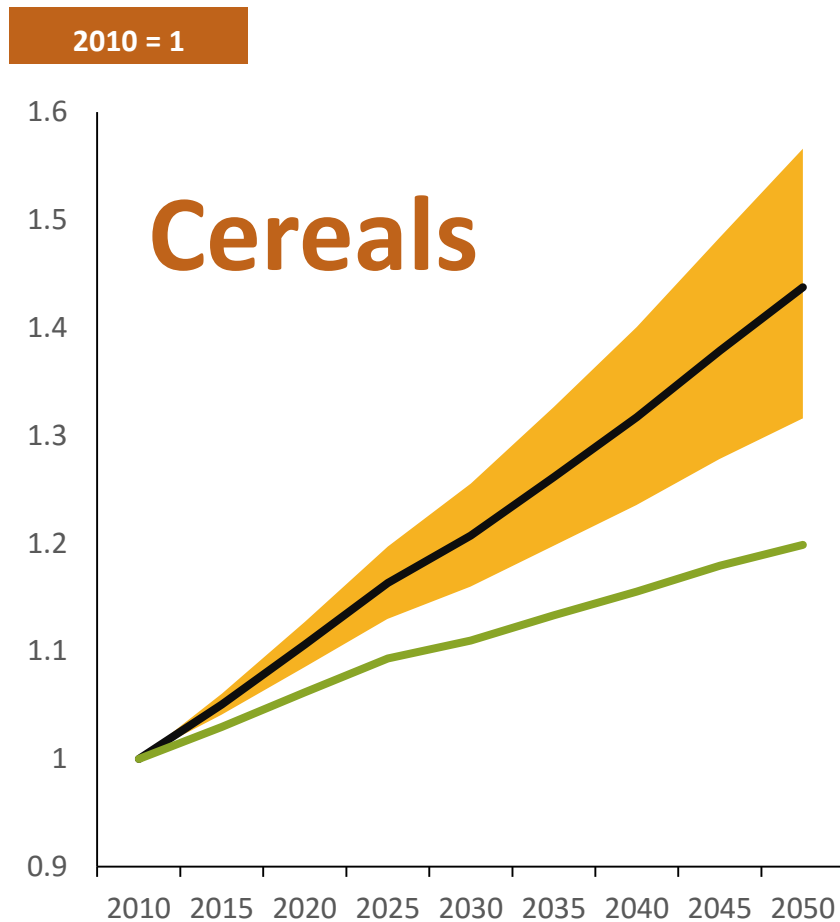
Global yields projected
30% lower in 2050 compared to
no climate change



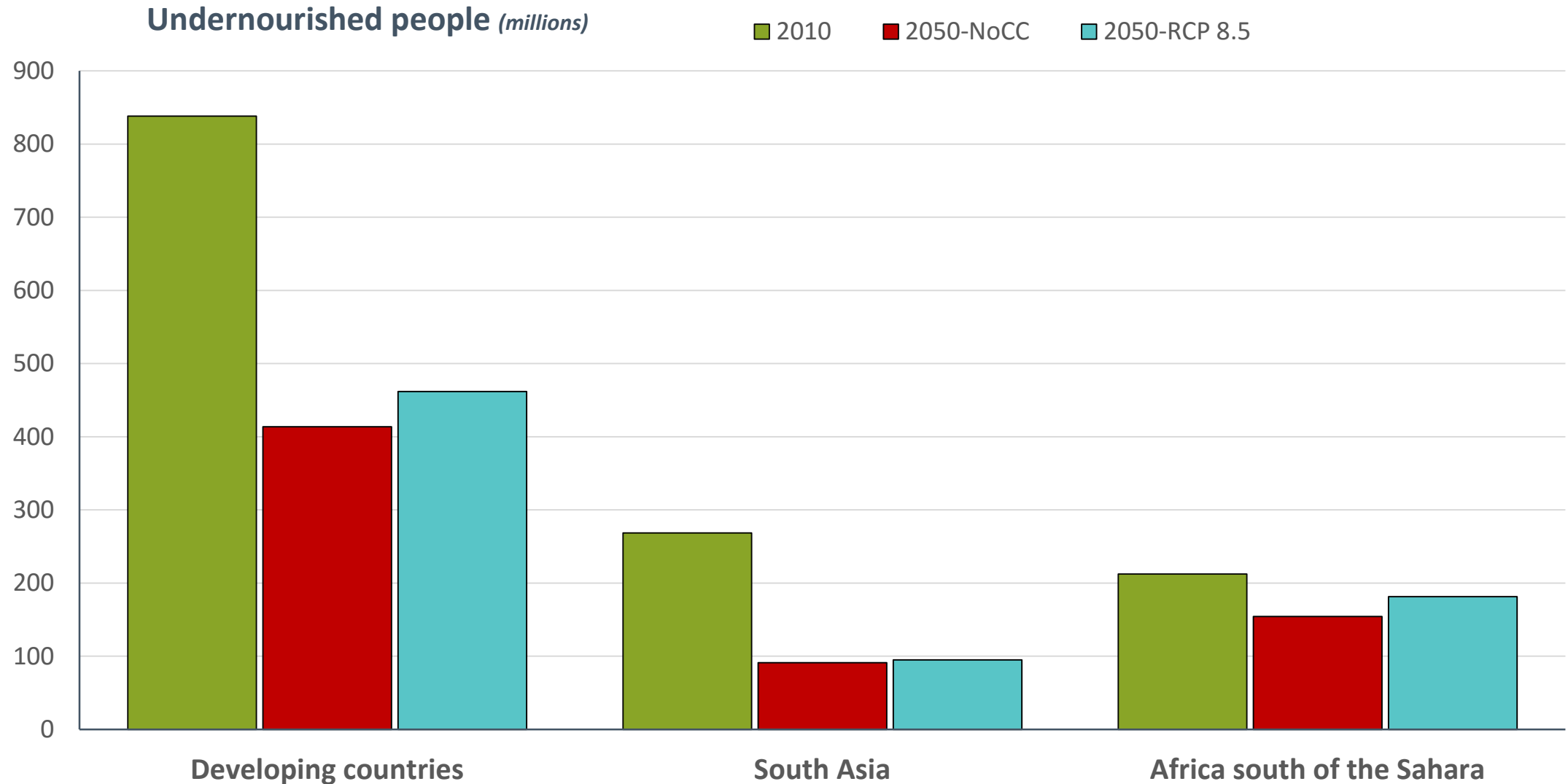
Source: IFPRI DSSAT simulations.

Food prices increase without climate change; even higher with climate change.

— No climate change
— Average with climate change
With climate change - range across models

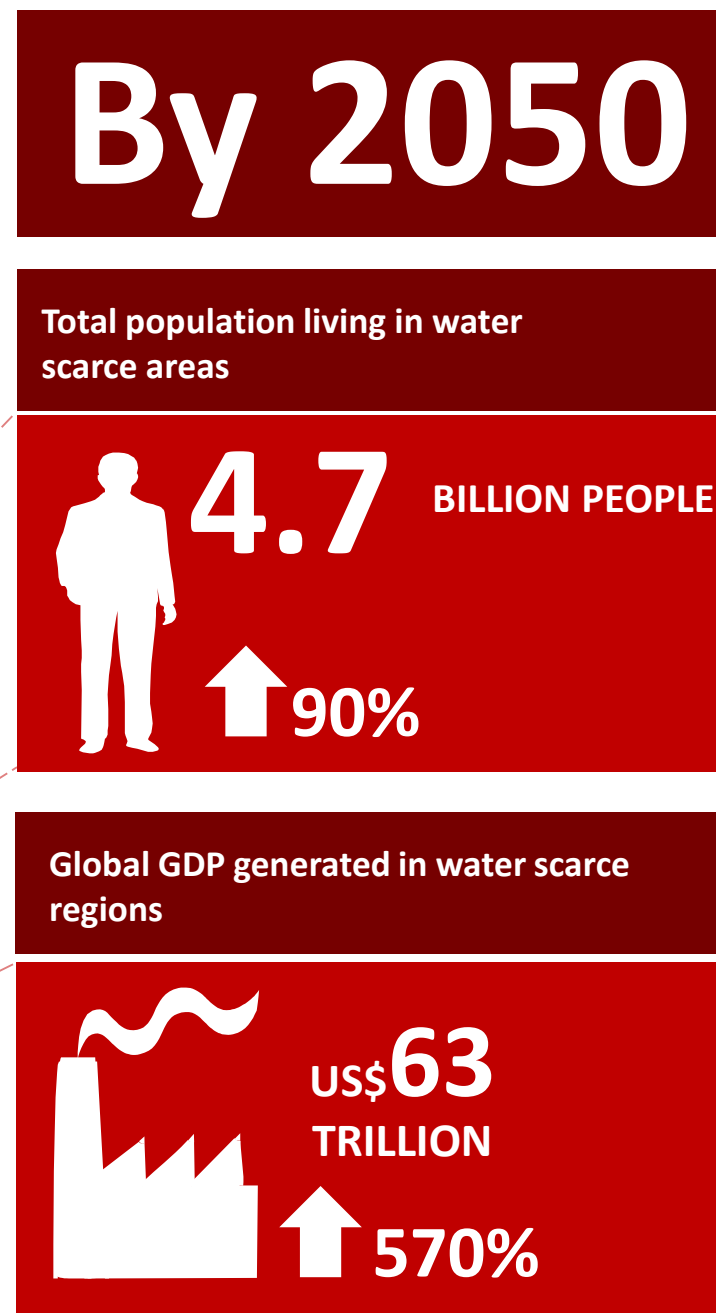


Improved progress on hunger, but too slow. Climate change increases hunger.

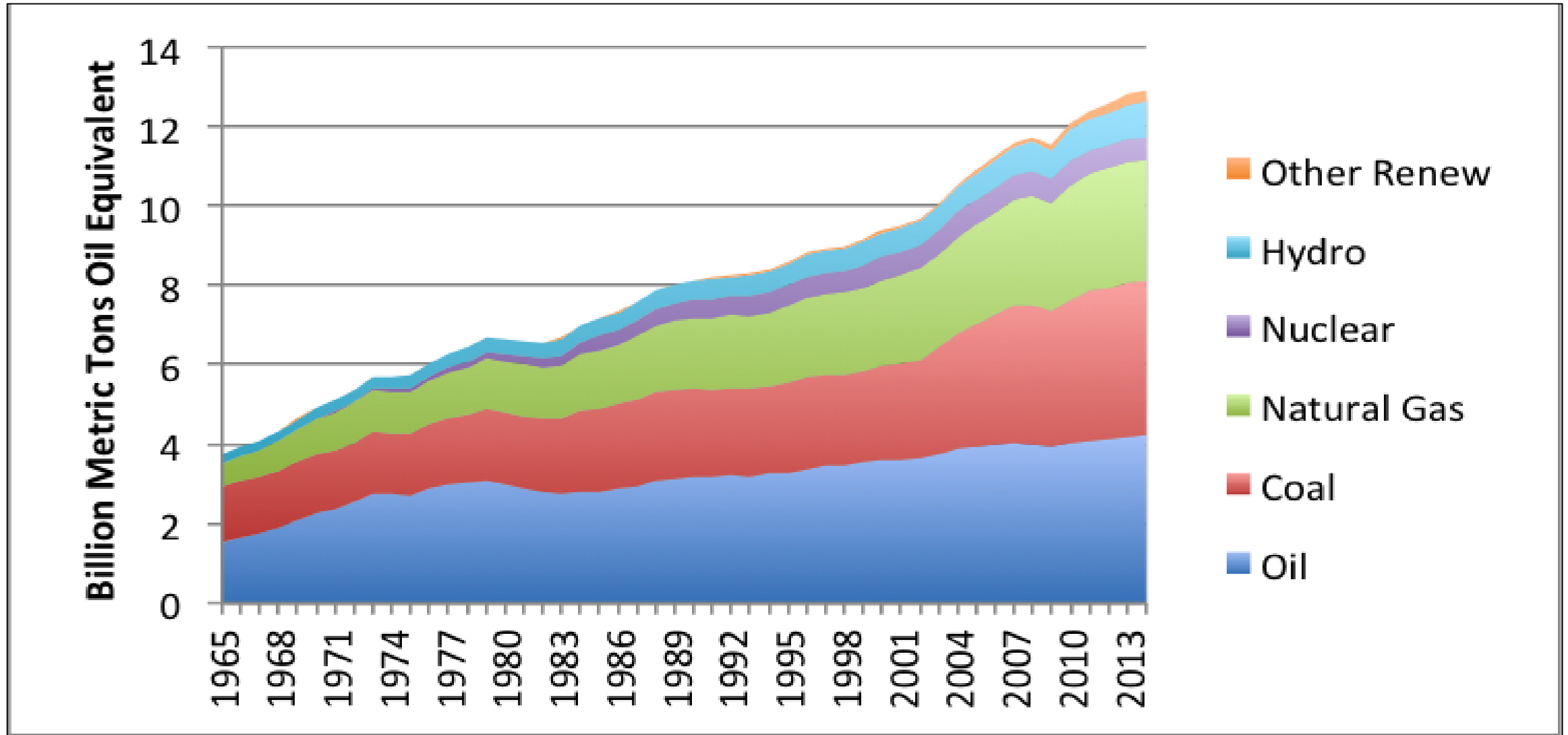


Source: IFPRI IMPACT 3.2 Projections.

Water stress risk



Fossil fuels continue to dominate energy consumption

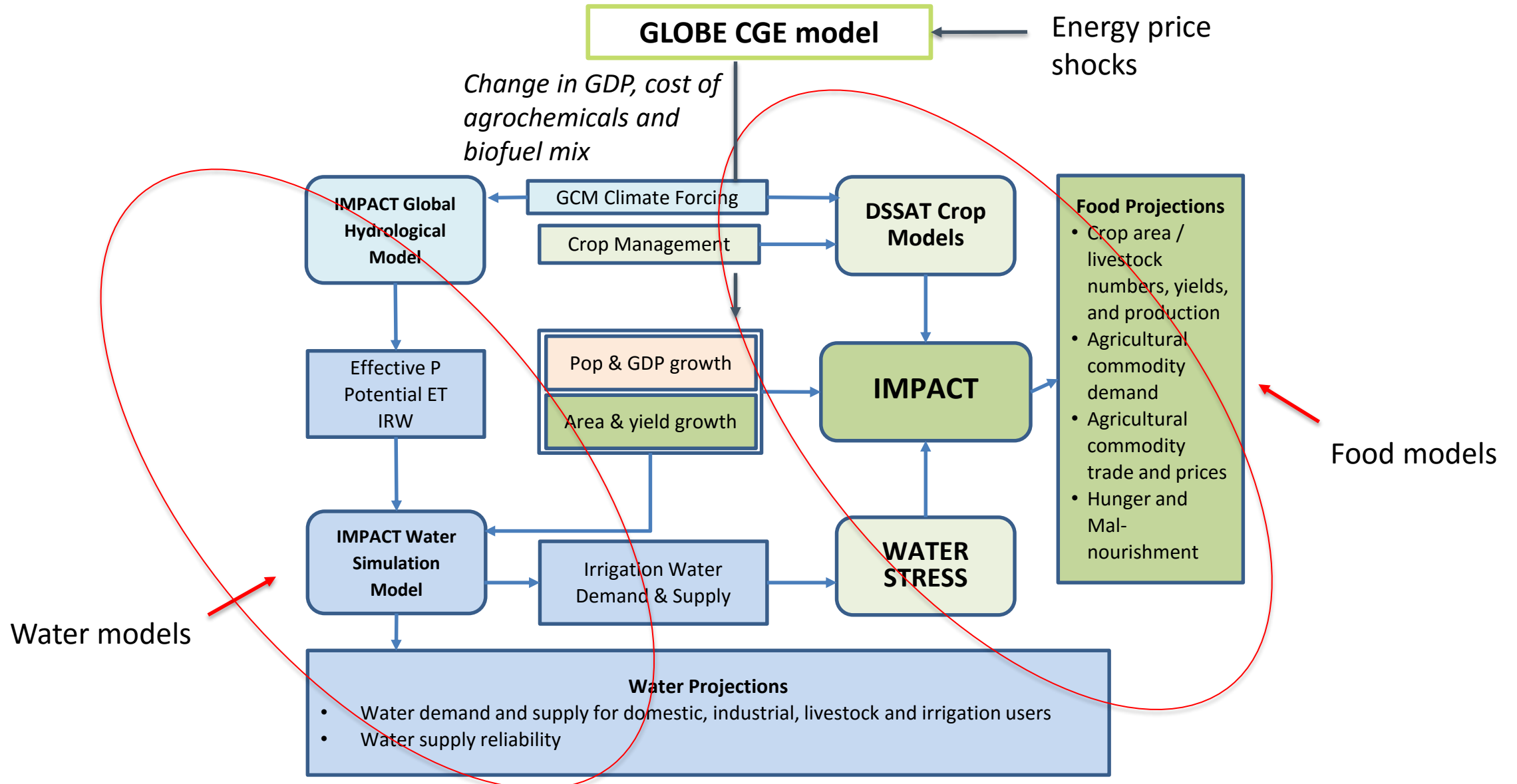


• ~60 percent of biomass is traditional biomass

Source: BP Statistical Review of World Energy 2015

Impact of Energy Taxes on Food Security and Water Scarcity: Scenarios to 2050

Method: IMPACT with CGE linkage



Analytical Framework: GLOBE CGE model

- Trade: Nested Armington specification: Imperfect substitutability between domestic goods and imports, and between imports by origin
- Product differentiation between output for domestic markets and exports, and between exports by destination (nested CET)
- Consumer demand derived from maximization of Stone-Geary utility functions => LES demand
- Producers maximize profits subject to CES-Leontief technologies and price taking behavior in input and output markets
- Calibration to GTAP 8.1 database (2013) and GTAP elasticities
- Aggregation 22 sectors – 22 regions – 5 primary factors

Analytical Framework: IMPACT Model

- Global partial equilibrium agricultural sector model
- Disaggregated agricultural commodities (56 commodities)
- Disaggregated spatial allocation of crop production at sub-national level (159 countries, and 320 food production units)
- Log-linear demand and supply functions
- Detailed structure of technology, land and water, and climate change
- World food prices are determined annually at levels that clear international commodity markets, demand, and supply

GLOBE-IMPACT linkage

- Model baselines are calibrated on agricultural productivity, GDP and prices and economy-wide gross domestic product (GDP)
- Climate shocks on agricultural productivity and prices are transmitted from IMPACT to GLOBE, with further iteration back to IMPACT for economy-wide feedbacks to agriculture
- Energy tax shocks on household income and GDP are transmitted from GLOBE to IMPACT

Scenarios

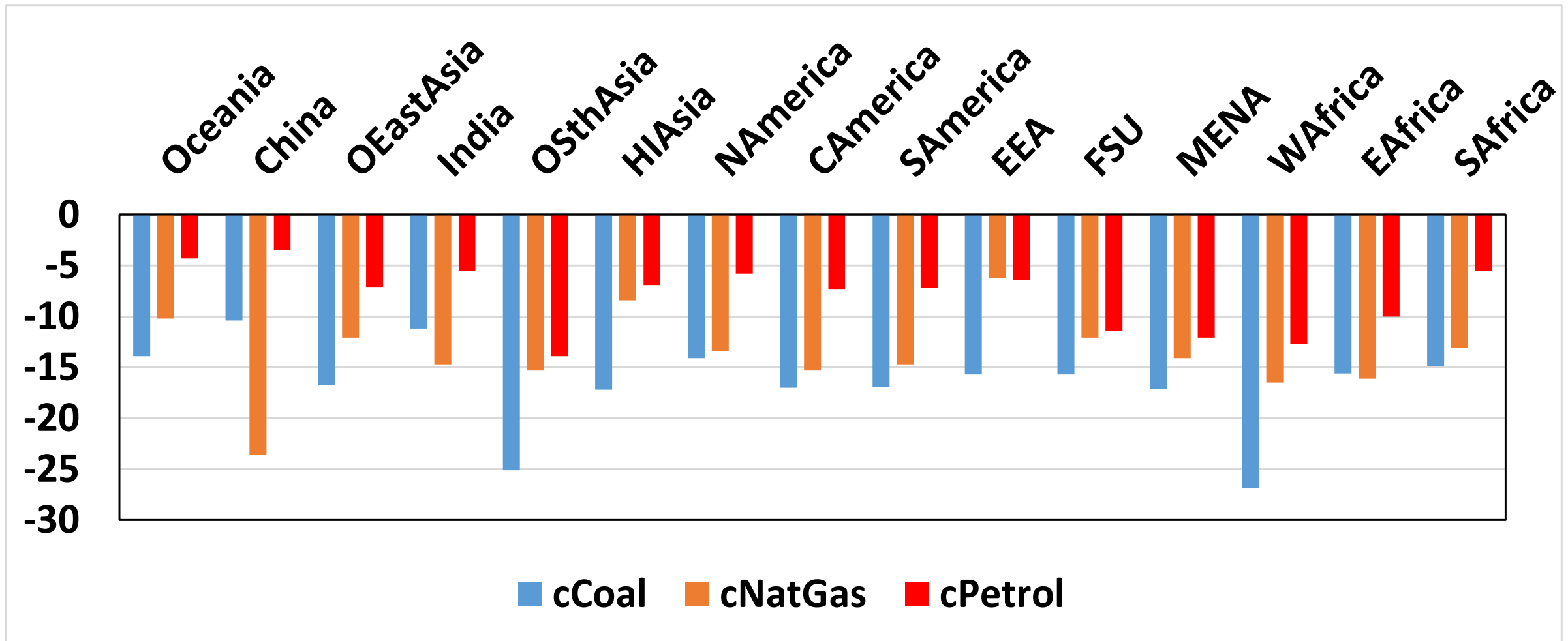
Scenario	Specification
1a Baseline without climate change (BasenoCC)	BAU (SSP2): 9.1 billion people in 2050
1b Baseline with climate change (BaseCC)	BAU (SSP2) with high emissions scenario (RCP8.5) and medium emissions (RCP6); HadGEM2-ES
2a High fossil fuel price without CC (HEPnoCC) 2b High fossil fuel price with CC (HEPCC); run with RCP8.5 and RCP6, which has slower increase in GHG emissions	Fossil fuel taxes in GLOBE impacting GDP and price of agricultural chemicals (70% tax on coal, 50% on crude oil; 30% on natural gas) Additional changes in IMPACT: Reduction of GW withdrawal capacity over 2015-2050; by 2050 20% lower than baseline to reflect adverse impacts of higher fuel prices on GW pumping
3a High fossil fuel price with increased biofuel use and increased hydropower production w/o CC (HEPadaptnoCC) 3b High fossil fuel price with increased biofuel use and increased HP production with CC (HEPadapCC)	Same as Scenario 2 plus Increase in First GEN biofuel demand to compensate for reduced fossil fuel availability, doubled by 2050 (GLOBE and IMPACT) Gradual, linear increase in hydropower production (10% by 2050) with associated 10% increase in storage and SW withdrawal capacity

Terms-of-Trade Effects (GLOBE)

	No Climate Change		With Climate Change	
	HEP	HEPadap	HEP	HEPadap
Oceania	(2.7)	(2.6)	(2.7)	(2.5)
China	0.9	0.9	0.9	0.8
O EastAsia	(1.2)	(1.2)	(1.2)	(1.2)
India	6.6	6.6	6.5	6.5
O SouthAsia	(3.9)	(3.9)	(3.9)	(3.9)
HIA Asia	5.2	5.1	5.1	5.0
N America	2.0	2.0	2.0	2.1
C America	(2.2)	(2.2)	(2.1)	(2.1)
S America	(1.1)	(0.9)	(1.1)	(0.8)
MENA	(6.0)	(6.1)	(5.9)	(6.0)
W Africa	(10.8)	(10.8)	(10.7)	(10.7)
E Africa	(5.1)	(5.1)	(5.1)	(5.1)
S Africa	1.6	1.6	1.5	1.5

- Energy price shifts cause terms-of-trade
 - gains for regions that are net importers of the primary fossil fuels
 - losses for the net exporters of these fuels (MENA)
- Regions that are simultaneously net importers of primary fossil fuels and net exporters of refined petrol enjoy the largest terms-of-trade gains (India and High-Income Asia)
- Regions that are both net exporters of primary fossil fuels and net importers of refined petrol (East and West Africa) have the biggest losses

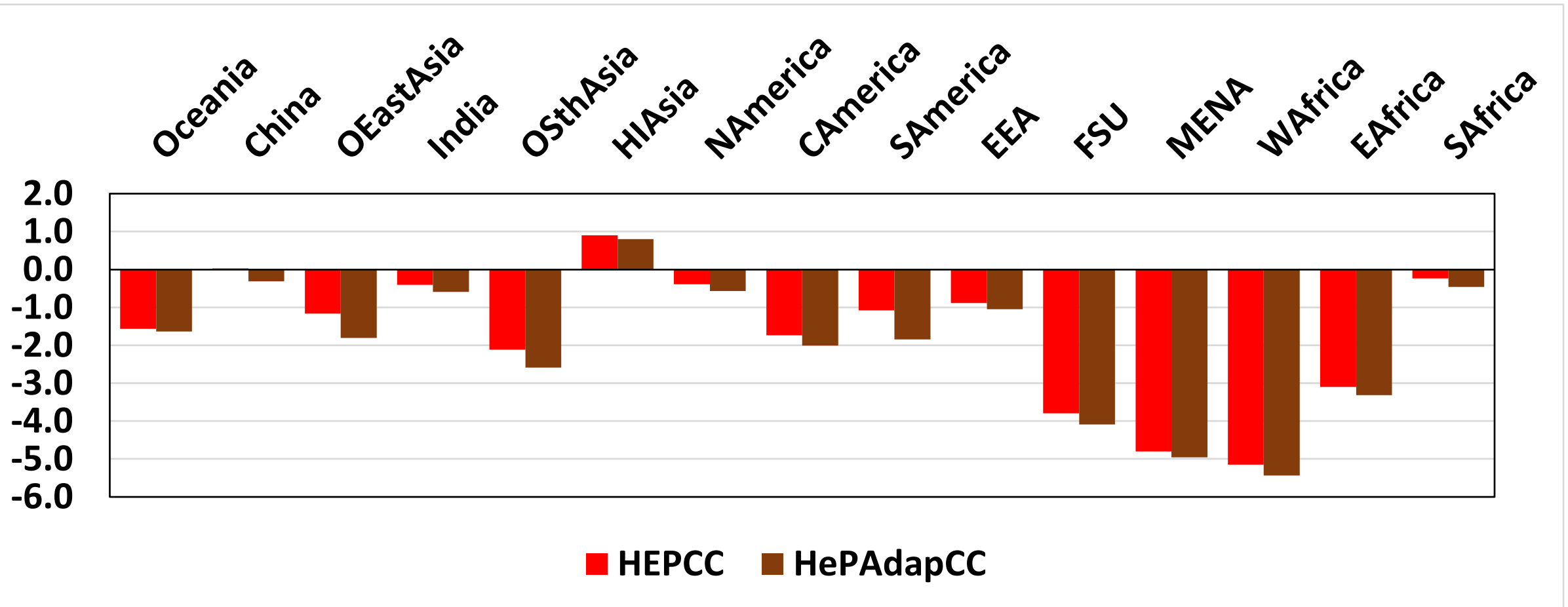
Change in fossil fuel use in electricity sector, HEPCC compared to BaseCC (%-change, 2050)



Note: Oceania: Australia, New Zealand and Other Oceania; OEastAsia – Other East Asia; OStthAsia – Other South Asia; HIAAsia – High-income Asia; NAmerica – North America; CAmerica – Central America and Caribbean; SAmerica – South America; EEA – European Economic Area; FSU – Former Soviet Union; MENA – Middle East and North America; WAfrica – West Africa; EAfrica – East and Central Africa; SAfrica – Southern Africa

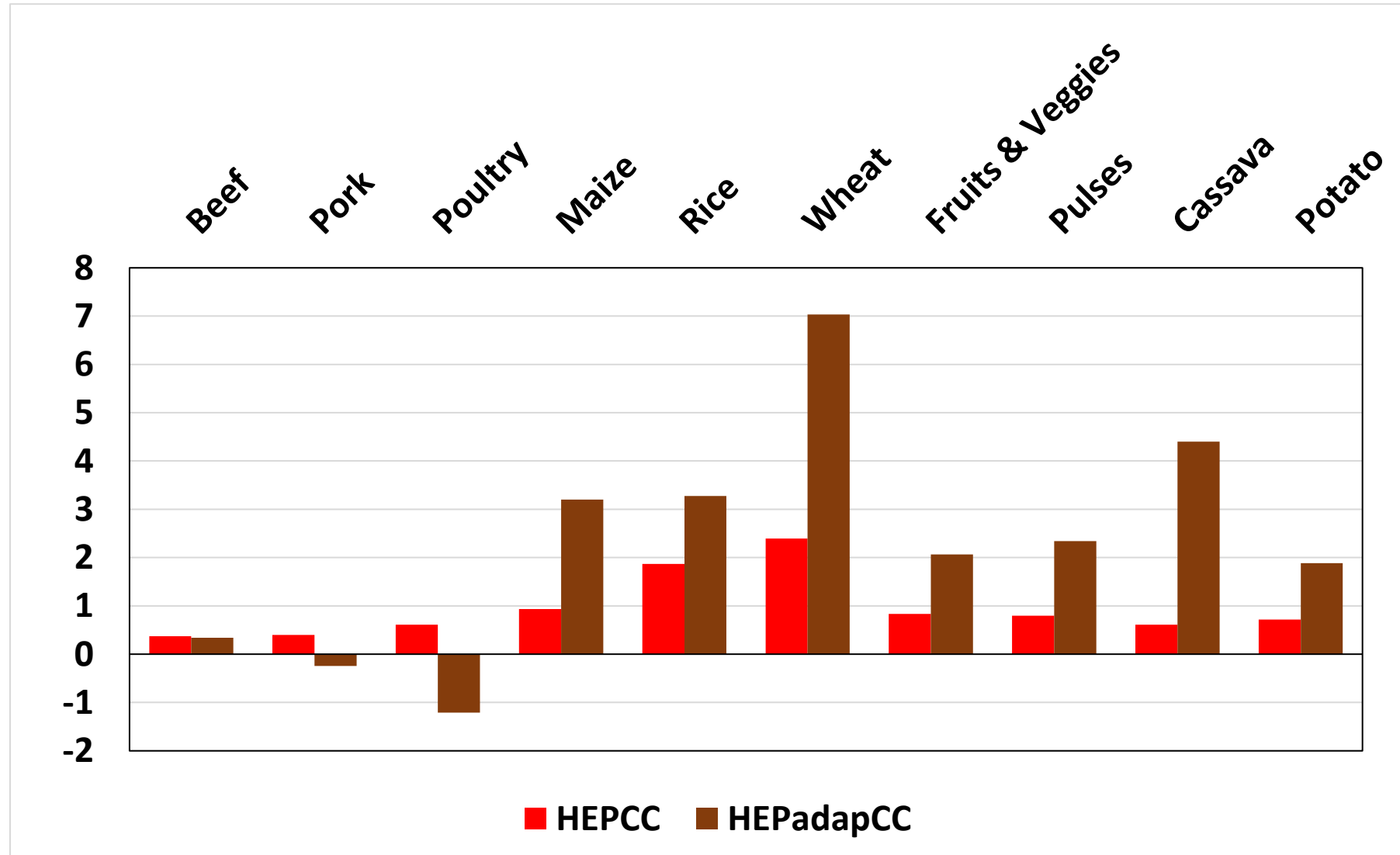
Source: Ringler et al., 2015

Impact of energy price increase on real household income (% deviation from baseline scenario)

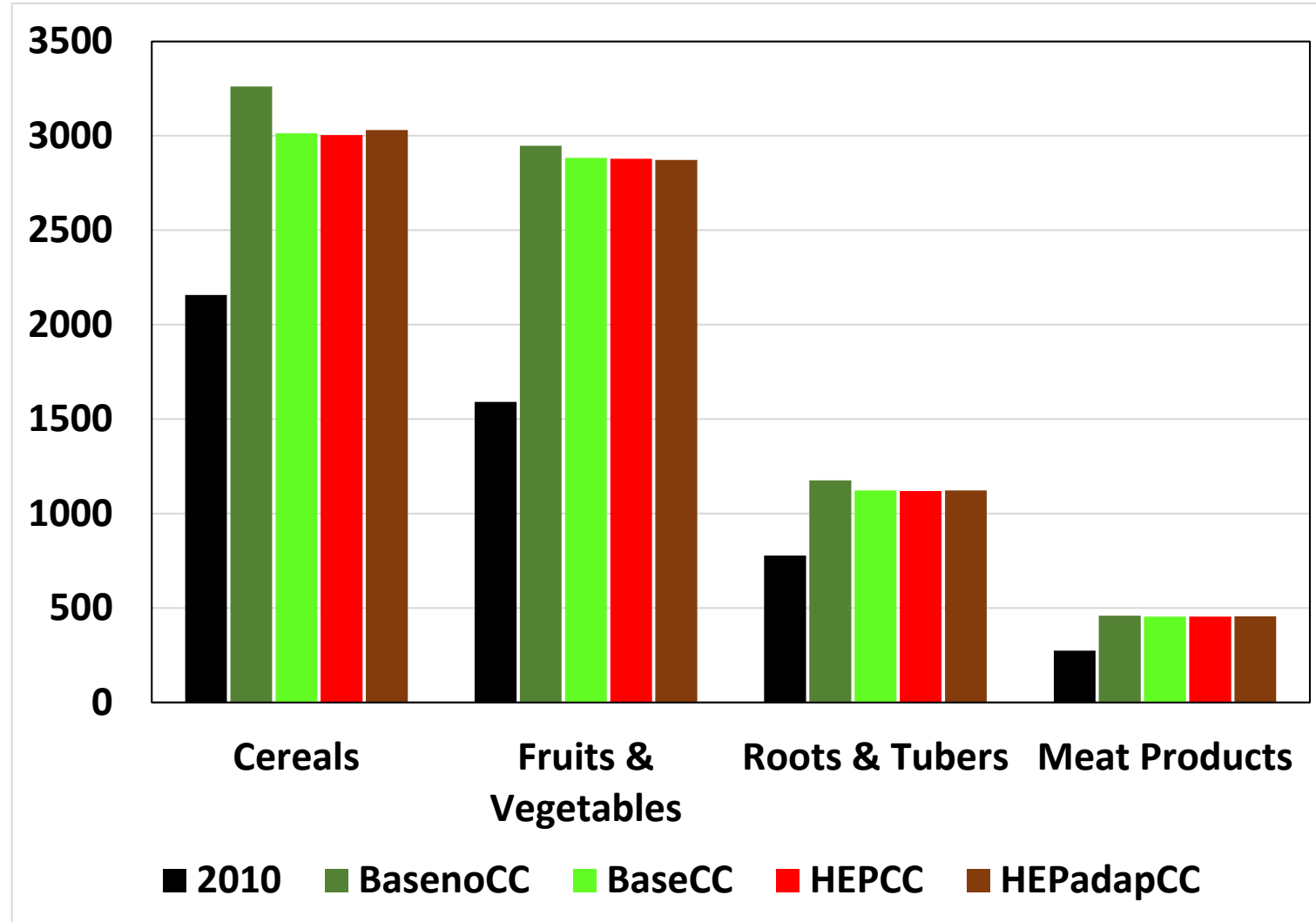


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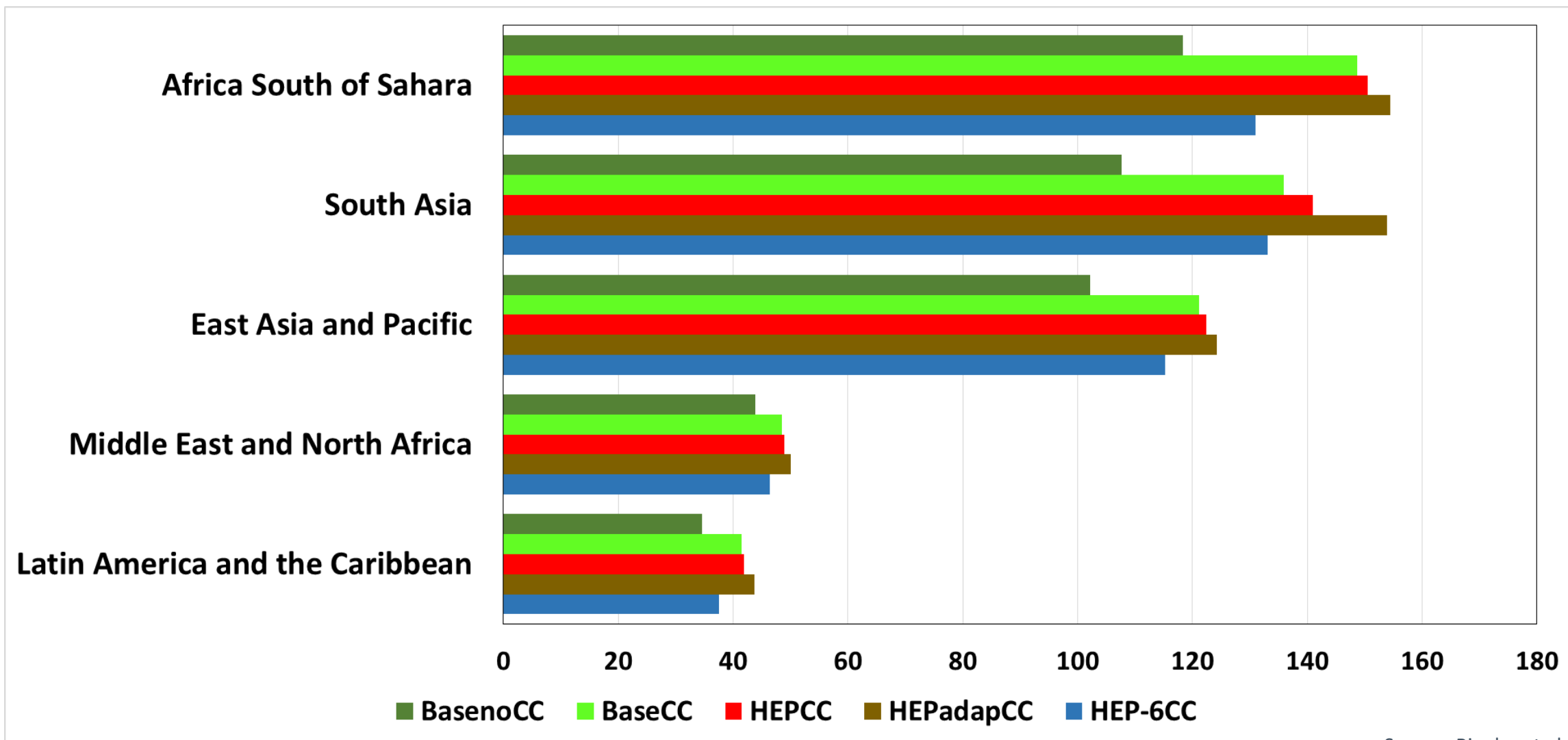
Changes in global food prices, alternative energy price scenarios (*%-change in 2050, compared to BaseCC*)



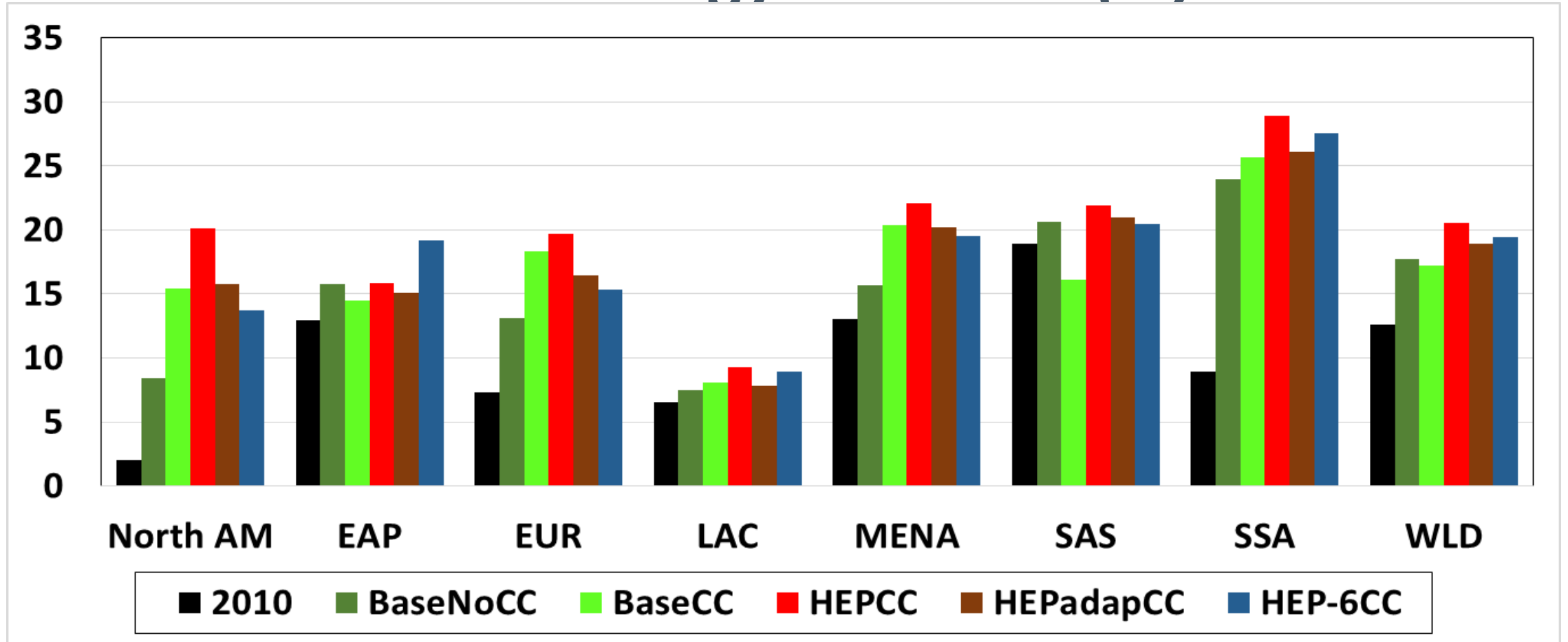
Global agricultural production, alternative energy scenarios (*million mt*)



Number of people at risk of hunger, 2050, alternative scenarios (*million people*)



Share of unmet water demands, 2010 and 2050 under alternative energy scenarios (%)



Share of consumptive use of water in all sectors that is not met either due to the lack of water availability, lack of investment or access (1 minus the ratio of total water supply to total water demand across the agriculture, livestock, industrial, and domestic sectors)

Note: North AM - North America; EAP - East Asia and Pacific; EUR - Europe; LAC - Latin America and Caribbean; MENA - Middle East and North Africa; SAS - South Asia; SSA - Sub Saharan Africa; WLD - World

Source: Ringler et al., 2015

Conclusions

Conclusions

- Climate change increases food prices and food insecurity
- Expansion of biofuel production increases the number of food insecure people
- Energy taxes
 - Significantly reduce fossil fuel consumption
 - Slightly reduce food supply due to higher agricultural chemical prices and reduced groundwater pumping,

Conclusions

- Energy taxes
 - Cause small reductions in household income, particularly in countries that are net exporters of fossil fuels or net importers of refined petrol
 - Slightly decrease food demand due to lower household income, leading to little or no change in food prices
 - Have variable impacts on water scarcity across regions depending on relative impacts on climate change and groundwater use
 - Improve food security with reduction in climate change intensity due to lower fossil fuel use